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Aruga

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(54) **PRINTING SYSTEM AND METHOD OF CONTROLLING PRINTING SYSTEM**

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(51) **Int. Cl.**
G06F 3/12 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/121*** (2013.01); ***G06F 3/1207*** (2013.01); ***G06F 3/1234*** (2013.01); ***G06F 3/1259*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/121; G06F 3/1207; G06F 3/1234; G06F 3/1259
USPC 358/1.14
See application file for complete search history.

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(57) **ABSTRACT**

A printing system includes a printing device and a cartridge. The printing device includes a controller that controls the printing device to perform printing by executing a plurality of sequences, an error detector that detects an error that is likely to occur in one or more of the plurality of sequences, and a first storage unit in which information is recorded by the controller. The cartridge includes a cartridge storage unit in which information is recorded by the controller in a state in which the cartridge is attached to the printing device. The controller records, in the first storage unit, numbers and results of a plurality of sequences. When the error is detected, the controller records numbers of a predetermined number of sequences including the latest sequenced among the numbers of the sequences recorded in the first storage unit.

10 Claims, 6 Drawing Sheets

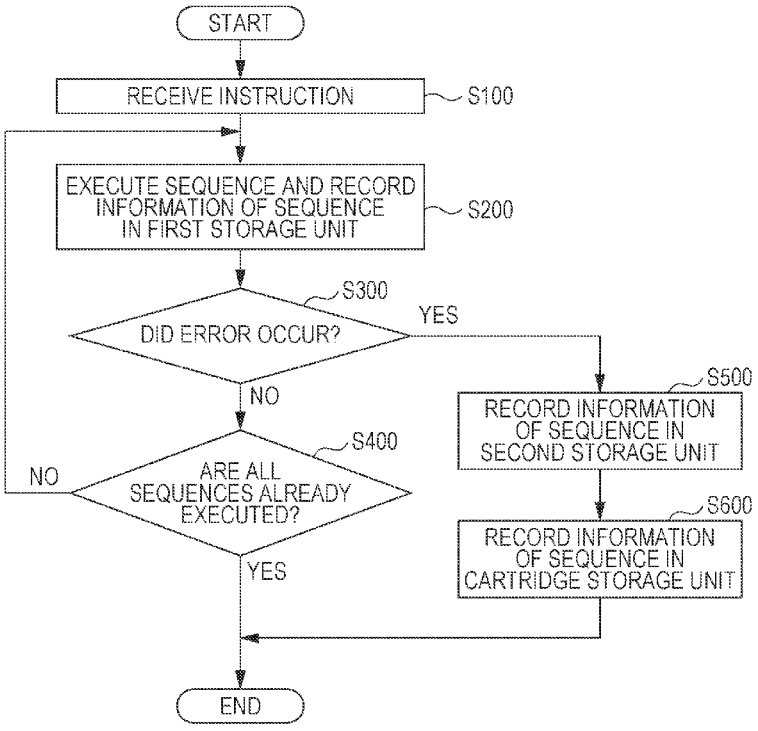


FIG. 1

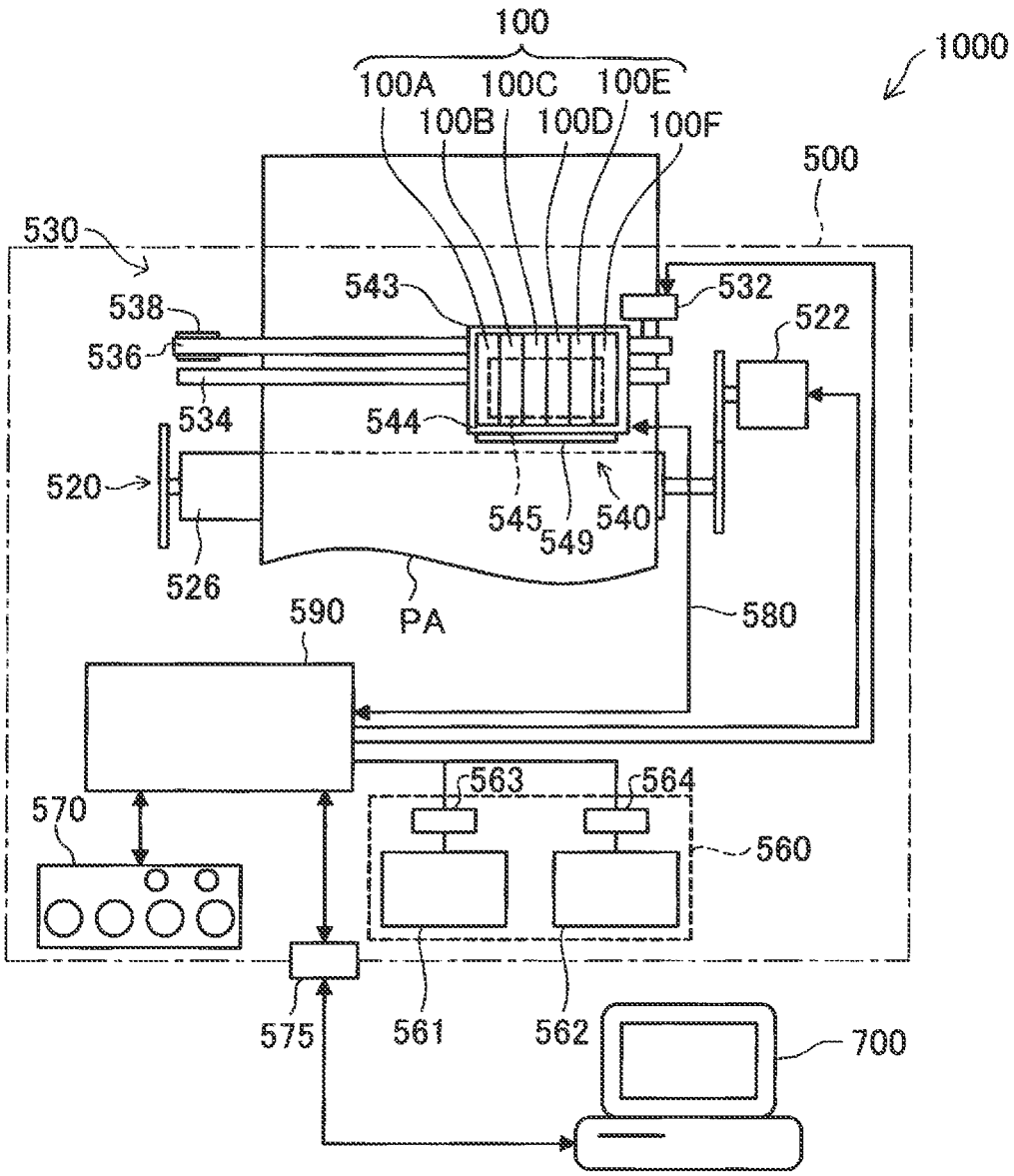

100
1000
100A
100C
100E
100B
100D
100F
500
530
543
532
538
522
536
534
544
520
545
549
540
526
PA
590
580
563
564
570
560
575
561
562
700

FIG. 2

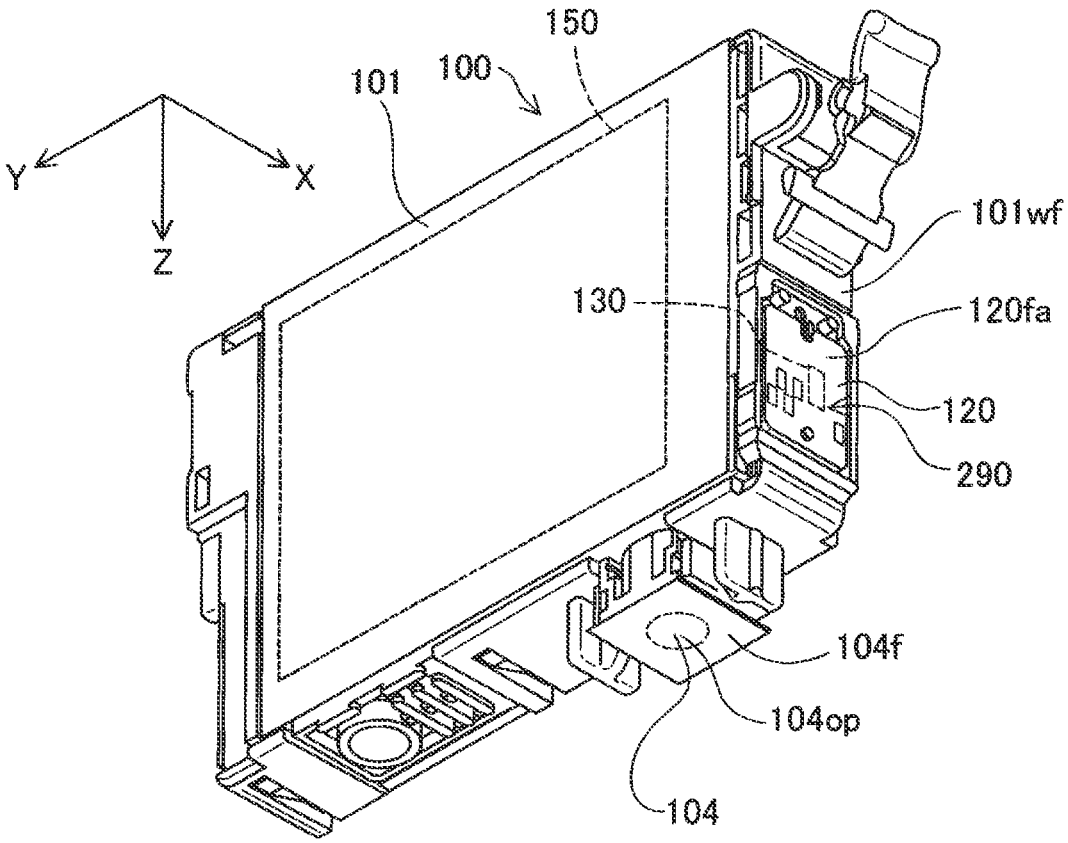


FIG. 3

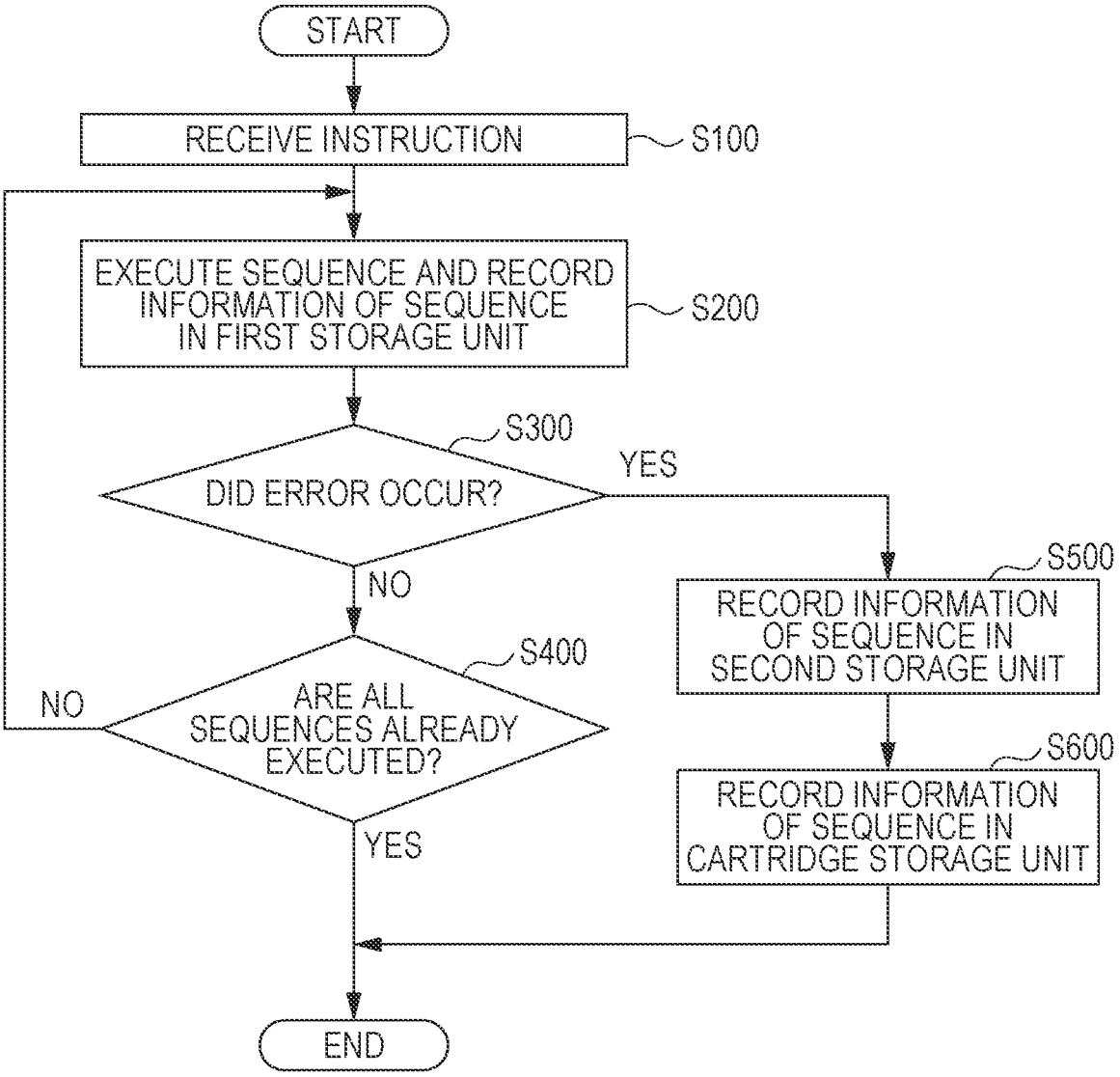

START
RECEIVE INSTRUCTION
S100
EXECUTE SEQUENCE AND RECORD INFORMATION OF SEQUENCE IN FIRST STORAGE UNIT
S200
S300
DID ERROR OCCUR?
YES
NO
S500
RECORD INFORMATION OF SEQUENCE IN SECOND STORAGE UNIT
S400
ARE ALL SEQUENCES ALREADY EXECUTED?
NO
YES
S600
RECORD INFORMATION OF SEQUENCE IN CARTRIDGE STORAGE UNIT
END

FIG. 4

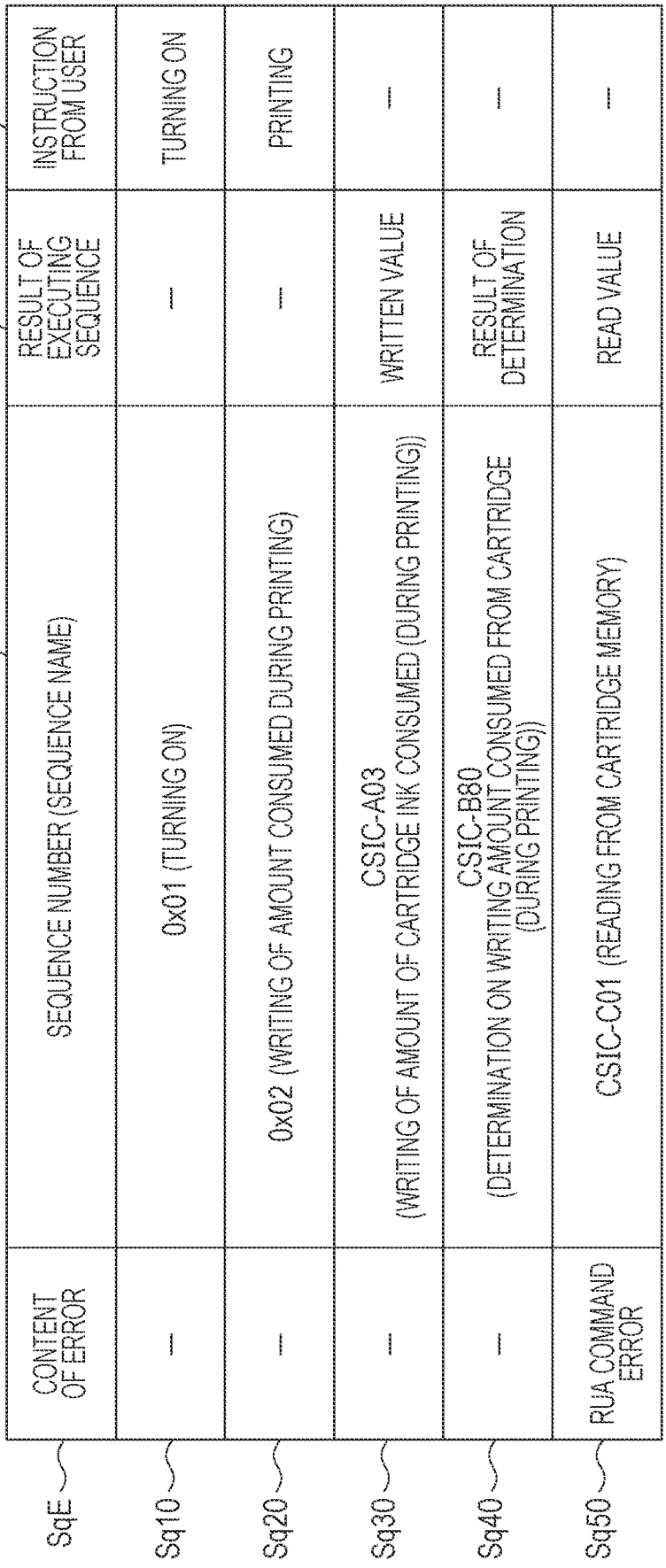

SqE
SqN
SqR
SqI
CONTENT OF ERROR
SEQUENCE NUMBER (SEQUENCE NAME)
RESULT OF EXECUTING SEQUENCE
INSTRUCTION FROM USER
Sq10
—
0x01 (TURNING ON)
—
TURNING ON
Sq20
—
0x02 (WRITING OF AMOUNT CONSUMED DURING PRINTING)
—
PRINTING
Sq30
—
CSIC-A03 (WRITING OF AMOUNT OF CARTRIDGE INK CONSUMED (DURING PRINTING))
WRITTEN VALUE
—
Sq40
—
CSIC-B80 (DETERMINATION ON WRITING AMOUNT CONSUMED FROM CARTRIDGE (DURING PRINTING))
RESULT OF DETERMINATION
—
Sq50
RUA COMMAND ERROR
CSIC-C01 (READING FROM CARTRIDGE MEMORY)
READ VALUE
—

FIG. 5

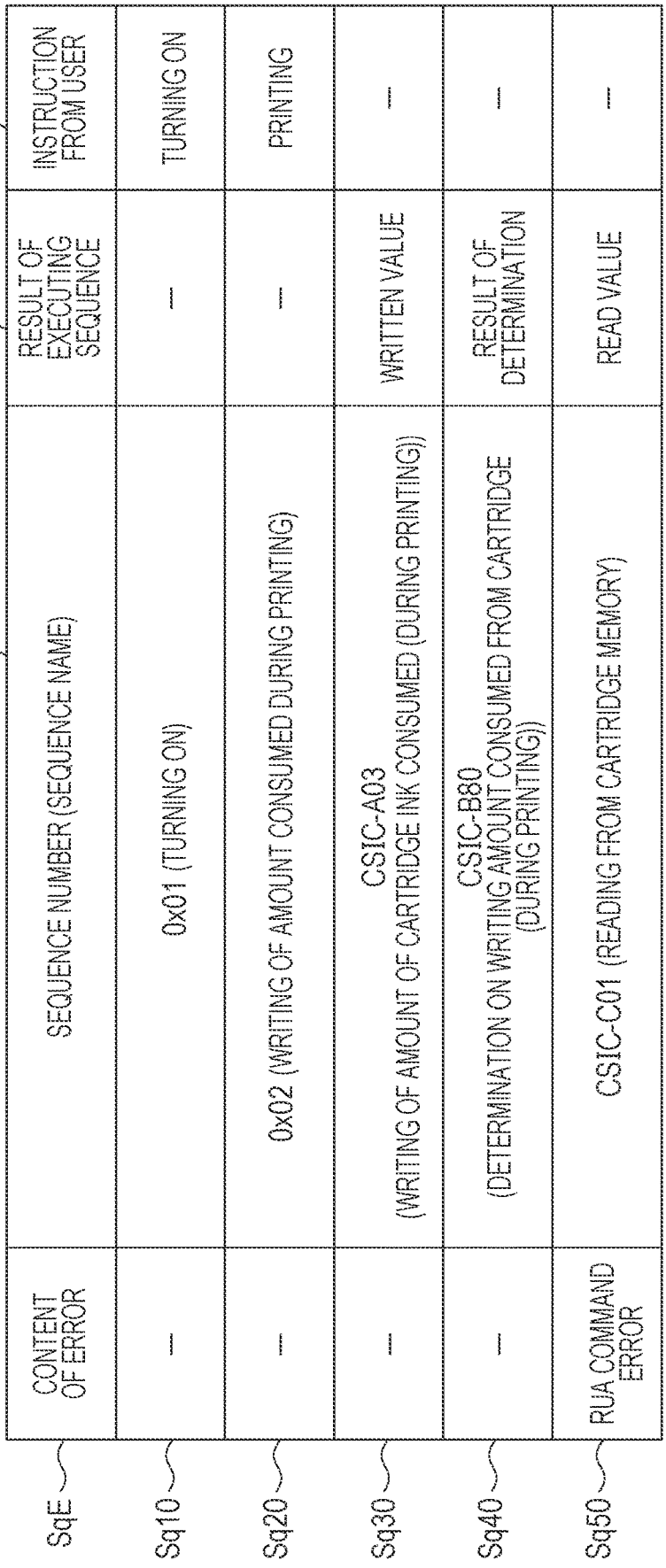
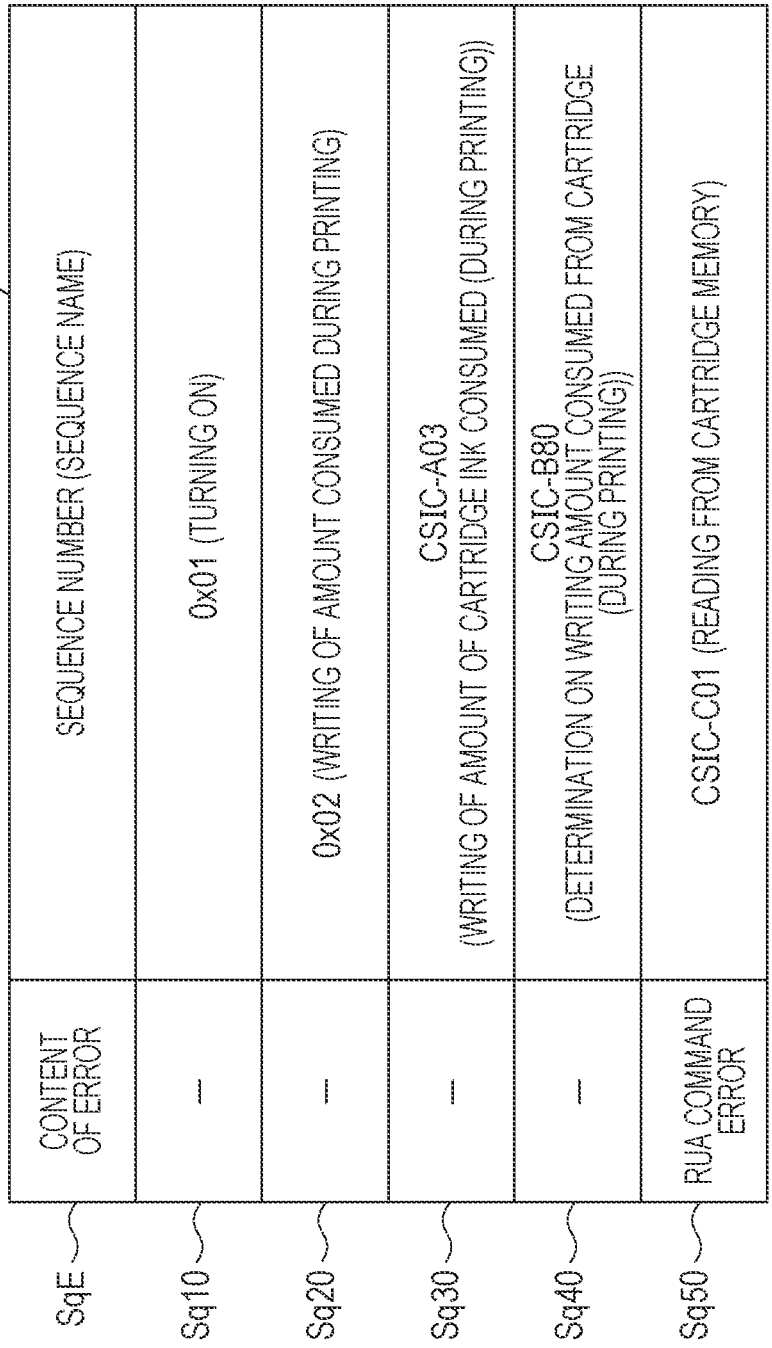

SqE
SqN
SqR
SqI
CONTENT OF ERROR
SEQUENCE NUMBER (SEQUENCE NAME)
RESULT OF EXECUTING SEQUENCE
INSTRUCTION FROM USER
Sq10
—
0x01 (TURNING ON)
—
TURNING ON
Sq20
—
0x02 (WRITING OF AMOUNT CONSUMED DURING PRINTING)
—
PRINTING
Sq30
—
CSIC-A03 (WRITING OF AMOUNT OF CARTRIDGE INK CONSUMED (DURING PRINTING))
WRITTEN VALUE
—
Sq40
—
CSIC-B80 (DETERMINATION ON WRITING AMOUNT CONSUMED FROM CARTRIDGE (DURING PRINTING))
RESULT OF DETERMINATION
—
Sq50
RUA COMMAND ERROR
CSIC-C01 (READING FROM CARTRIDGE MEMORY)
READ VALUE
—

FIG. 6


SqN
SqE
CONTENT OF ERROR
SEQUENCE NUMBER (SEQUENCE NAME)
Sq10
—
0x01 (TURNING ON)
Sq20
—
0x02 (WRITING OF AMOUNT CONSUMED DURING PRINTING)
Sq30
—
CSIC-A03
(WRITING OF AMOUNT OF CARTRIDGE INK CONSUMED (DURING PRINTING))
Sq40
—
CSIC-B80
(DETERMINATION ON WRITING AMOUNT CONSUMED FROM CARTRIDGE (DURING PRINTING))
Sq50
RUA COMMAND ERROR
CSIC-C01 (READING FROM CARTRIDGE MEMORY)

PRINTING SYSTEM AND METHOD OF CONTROLLING PRINTING SYSTEM

The present application is based on, and claims priority from JP Application Serial Number 2022-084937, filed May 25, 2022, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

The present disclosure relates to a printing system and a method of controlling a printing system.

2. Related Art

A facsimile that outputs information regarding an error is present. When an error occurs during a transmission operation, a reception operation, or a copy operation in a facsimile described in JP-A-2006-150889, the facsimile stores the status of a video interface (I/F) and the cause of the error in a nonvolatile memory. The cause of the error is the state of a paper presence sensor, the state of a paper position sensor, the temperature of a heater, or a timer value. When the error is an error of a recording system, the status of the recording system and the cause of the error are printed. When the error is not an error of the recording system, an error code is displayed or printed.

When an error occurs in the facsimile described in JP-A-2006-150889, the status of the recording system, and the state of a sensor, the temperature of the heater, or the timer value after the occurrence of the error is printed or an error code is printed. However, it may not be possible to estimate the cause of the error only from the error code and information indicating the state of the device at the time of the occurrence of the error.

SUMMARY

According to an aspect of the present disclosure, a printing system is provided. The printing system includes a printing device that performs printing and a cartridge that is used for the printing and detachably attached to the printing device. The printing device includes a controller that controls the printing device to perform the printing by executing a plurality of sequences, an error detector that detects an error that is likely to occur in one or more of the plurality of sequences, and a first storage unit in which information is recorded by the controller. The cartridge includes a cartridge storage unit that is a nonvolatile storage unit and in which information is recorded by the controller in a state in which the cartridge is attached to the printing device. The controller records, in the first storage unit, numbers and results of a plurality of sequences including the latest sequence among the plurality of sequences executed. When the error is detected, the controller records, in the cartridge storage unit, numbers of a predetermined number of sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an explanatory diagram illustrating a schematic configuration of a printing system.

FIG. **2** is a perspective view illustrating a configuration of an ink cartridge.

FIG. **3** is a flowchart illustrating a control method to be performed when printing is performed in the printing system.

FIG. **4** is a table illustrating an example of information recorded in a first storage unit.

FIG. **5** is a table illustrating an example of information recorded in a second storage unit after processing in step S**500**.

FIG. **6** is a table illustrating an example of information recorded in a memory chip after processing in step S**600**.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

A. First Embodiment

A1. Hardware Configuration

FIG. **1** is an explanatory diagram illustrating a schematic configuration of a printing system **1000**. The printing system **1000** includes a printing device **500**, a plurality of ink cartridges **100**, and a computer **700**.

The printing device **500** performs printing by ejecting ink onto a print medium PA. Specifically, the printing device **500** is an ink jet printer. The plurality of ink cartridges **100**A to **100**F are detachably attached to the printing device **500**. The printing device **500** is connected to the computer **700**. The printing device **500** includes an auxiliary scan feeding mechanism **520**, a main scan feeding mechanism **530**, a head drive mechanism **540**, a storage unit **560**, an operation unit **570**, a connector **575**, a bus **580**, and a main controller **590**.

The auxiliary scan feeding mechanism **520** transports the print medium PA in an auxiliary scan direction. The auxiliary scan feeding mechanism **520** includes a paper feeding motor **522** and a roller **526**. The rotation of the paper feeding motor **522** is transmitted to the roller **526** so as to transport the print medium PA in contact with the roller **526** in the auxiliary scan direction.

The main scan feeding mechanism **530** causes a carriage **543** of the head drive mechanism **540** to reciprocate in a main scan direction that is the axis direction of the roller **526**. The main scan feeding mechanism **530** includes a carriage motor **532**, a sliding shaft **534**, a drive belt **536**, and a pulley **538**.

The sliding shaft **534** is disposed parallel to the axis of the roller **526**. The sliding shaft **534** holds the carriage **543** fixed to the drive belt **536** such that the carriage **543** is slidable. The drive belt **536** couples an output shaft of the carriage motor **532** to the pulley **538**. The drive belt **536** is an endless belt. The rotational motion of the output shaft of the carriage motor **532** is transmitted as a reciprocation motion to the carriage **543** via the drive belt **536**. As a result, the carriage **543** reciprocates along the sliding shaft **534** in the main scan direction.

The head drive mechanism **540** receives ink from the ink cartridges **100** and ejects the ink onto the print medium PA. The head drive mechanism **540** includes the carriage **543**.

The ink cartridges **100** are detachably attached to the carriage **543**, and the carriage **543** ejects the ink received from the ink cartridges **100** onto the print medium PA. The carriage **543** includes a holder **544**, a print head **545**, and a sub-control substrate **549**.

The holder **544** can hold the six ink cartridges **100**A to **100**F. In the ink cartridges **100**A to **100**F, the ink of different colors or types is stored. In the present specification, when the ink cartridges **100**A to **100**F are described without being distinguished, each of the ink cartridges **100**A to **100**F is referred to as an ink cartridge **100**.

The print head **545** is coupled to the ink cartridge **100** held by the holder **544** and ejects ink received from the ink cartridge **100** onto the print medium PA. The sub-control substrate **549** controls the print head **545**.

The main controller **590** records information in the storage unit **560**. The storage unit **560** includes a first storage unit **561**, a second storage unit **562**, a first recording controller **563**, and a second recording controller **564**.

The main controller **590** records information in the first storage unit **561** and the second storage unit **562**. The first storage unit **561** is a volatile storage unit. The second storage unit **562** is a nonvolatile storage unit. Specifically, the first storage unit **561** is a volatile semiconductor memory, and the second storage unit **562** is a nonvolatile semiconductor memory. The second storage unit **562** stores, for example, a computer program to be executed by a central processing unit (CPU) that is a processor of the main controller **590**. The computer program in the second storage unit **562** is loaded into the first storage unit **561** and executed by the CPU of the main controller **590**. As a result, the main controller **590** implements various functions.

The first recording controller **563** performs processing of writing to the first storage unit **561** and processing of reading from the first storage unit **561** in accordance with an instruction from the CPU of the main controller **590**. The first recording controller **563** detects an error that is likely to occur in processing of writing to the first storage unit **561** and an error that is likely to occur in processing of reading from the first storage unit **561**. For example, the processing of writing to the first storage unit **561** and the processing of reading from the first storage unit **561** are included in a plurality of sequences executed by the CPU of the main controller **590** in printing.

The second recording controller **564** performs processing of reading from the second storage unit **562** in accordance with an instruction from the CPU of the main controller **590**. The second recording controller **564** detects an error that is likely to occur in the processing of reading from the second storage unit **562**. For example, the processing of reading from the second storage unit **562** is included in a plurality of sequences executed in printing.

The operation unit **570** is operated by a user to notify the main controller **590** of an instruction from the user (refer to a lower left part of FIG. **1**). Specifically, the operation unit **570** includes a liquid crystal panel including a touch panel, and a hardware switch.

The connector **575** is coupled to a connection line connecting the printing device **500** to the computer **700** (refer to a lower central part of FIG. **1**). The connector **575** receives an instruction from the user via the computer **700** and transmits the instruction to the main controller **590**.

The main controller **590** controls the above-described mechanisms to implement a printing process (refer to a middle left part of FIG. **1**). The main controller **590** includes the CPU as the processor. The main controller **590** controls the printing device **500** to perform printing by performing a plurality of sequences.

The main controller **590** is coupled to the sub-control substrate **549** of the carriage **543** and a memory chip **130** of the ink cartridge **100** via the bus **580**. The main controller **590** is coupled to the operation unit **570**. The main controller **590** is connected to the computer **700** via the connector **575** and a wired connection. The main controller **590** receives a print job from the computer **700** and controls the above-described mechanisms to perform a printing operation based on the content of the received print job.

FIG. **2** is a perspective view illustrating a configuration of the ink cartridge **100**. FIG. **2** illustrates an X axis, a Y axis, and a Z axis that are perpendicular to each other. FIG. **2** illustrates the printing device **500** disposed on a horizontal surface parallel to the X direction and the Y direction, and the ink cartridge **100** attached to the printing device **500**.

The ink cartridge **100** is detachably attached to the printing device **500**. The ink cartridge **100** is attached to the printing device **500** and supplies the ink to the printing device **500**. The ink cartridge **100** has a substantially rectangular parallelepiped outer shape. The ink cartridge **100** includes a body **101** for storing the ink and a memory substrate **120**.

The body **101** includes an ink chamber **150** and an input supply port **104**. The ink chamber **150** stores the ink. The ink supply port **104** communicates with the ink chamber **150** through an ink supply path. The ink within the ink chamber **150** is supplied to the carriage **543** of the printing device **500** through the ink supply port **104** (refer to an upper central part of FIG. **1**). An opening **104***op* of the ink supply port **104** is sealed by a film **104***f*. By attaching the ink cartridge **100** to the carriage **543**, the film **104***f* is torn and the ink cartridge **100** communicates with the outside of the opening **104***op* of the ink supply port **104**.

The memory substrate **120** is disposed on a front wall **101***wf* of the body **101**. The memory substrate **120** includes the memory chip **130** and a plurality of memory terminals **290**.

The memory chip **130** is disposed on a back surface of the memory substrate **120** (refer to a middle right part of FIG. **2**). The memory chip **130** is a semiconductor storage device including a processing unit and a memory cell. The memory cell of the memory chip **130** is a nonvolatile storage unit. The processing unit is synchronized with a clock signal having a predetermined frequency and transmitted from the printing device **500** to communicate various types of information with the printing device **500**. The main controller **590** of the printing device **500** records information in the memory chip **130** in a state in which the ink cartridge **100** is attached to the printing device **500**.

The plurality of memory terminals **290** are disposed on a front surface **120***fa* of the memory substrate **120**. The memory terminals **290** are formed of a conductor such as gold foil. The plurality of memory terminals **290** are coupled to the memory chip **130** via a circuit disposed in the memory substrate **120**. The plurality of memory terminals **290** are coupled to terminals disposed in the holder **544** of the printing device **500** in a state in which the ink cartridge **100** is attached to the printing device **500**. The terminals disposed in the holder **544** are coupled to the bus **580**. Therefore, in a state in which the ink cartridge **100** is attached to the printing device **500**, the processing unit of the memory chip **130** of the ink cartridge **100** is coupled to the sub-control substrate **549** and the main controller **590** of the printing device **500**.

A2. Processing in Printing System **1000**

FIG. **3** is a flowchart illustrating a control method to be performed when printing is performed in the printing system **1000**. A process illustrated in FIG. **3** is performed by the main controller **590** of the printing device **500**. The process illustrated in FIG. **3** is repeatedly performed after the printing device **500** is turned on.

In step S**100**, the main controller **590** receives an instruction to perform the process from the user. Specifically, the instruction to perform the process may be input from the user via the operation unit **570** of the printing device **500**. Alternatively, the instruction to perform the process may be

input to the computer **700** from the user and input to the printing device **500** via the connector **575** of the printing device **500**.

In step S**200**, the main controller **590** executes one of one or more sequences to be executed in response to the instruction received from the user in step S**100**. When step S**200** is performed for the first time after step S**100**, the first sequence of the one or more sequences to be executed in response to the instruction received in step S**100** is executed.

When the main controller **590** completes the one sequence, the main controller **590** records information of the completed sequence in the first storage unit **561** of the printing device **500** (refer to a lower central part of FIG. **1**). Specifically, when the main controller **590** completes the one sequence, the main controller **590** records, in the first storage unit **561**, a combination of the content SqE of an error that occurred in the sequence, a number SqN of the sequence, a result SqR of the sequence, and the instruction SqI from the user that triggered the sequence, as information of the sequence. The first storage unit **561** is a volatile semiconductor memory (refer to a lower central part of FIG. **1**).

FIG. **4** is a table illustrating an example of information recorded in the first storage unit **561**. FIG. **4** illustrates a state in which sequences Sq**20** to Sq**50** among a plurality of sequences Sq**20** to Sq**90** to be executed in printing after a sequence Sq**10** executed in response to the turning on of the printing device **500** are completed. The number of sequences to be executed in the printing is exemplified as 9 to easily understand the techniques and does not reflect the actual number of sequences.

In FIG. **4**, the leftmost column indicates the content SqE of an error. In FIG. **4**, "-" indicates that a value is not recorded. In the example illustrated in FIG. **4**, an error does not occur in the sequences Sq**10** to Sq**40** and the error occurs in the sequence Sq**50**. The error that occurs in the sequence Sq**50** is a "RUA command error" (refer to a lower left part of FIG. **4**). The RUA command error occurs when reading of data from a nonexistent, unallocated, or unmapped memory is tried.

In FIG. **4**, the second column from the left indicates sequence numbers SqN. The sequence numbers SqN are numbers that uniquely represent the sequences. To easily understand the techniques, FIG. **4** illustrates sequence names in brackets to the right of the sequence numbers SqN. The sequences may be executed in different processes. The different processes are, for example, printing in black and photographic printing. When the same sequence is executed in different processes, a combination of sequences executed before the execution of the sequence is different from a combination of sequences executed after the execution of the sequence in each of the processes.

In FIG. **4**, the third column from the left indicates results SqR of executing the sequences. The results SqR of executing the sequences are information written to the first storage unit **561** as a result of executing the sequences. The result SqR of executing each of the sequences includes a larger amount of information than that of the content SqE of the error and that of each of the numbers SqN of the sequences.

In a write sequence, a result SqR of executing the sequence is a written value. In a determination sequence, a result SqR of executing the sequence is a value indicating the result of the determination. In a read sequence, a result SqR of executing the sequence is a read value. To easily understand the techniques, FIG. **4** illustrates technical meanings of written values instead of specifically recorded values.

In FIG. **4**, the rightmost column indicates instructions SqI from the user that triggered the sequences. To easily understand the techniques, FIG. **4** illustrates technical meanings of written values instead of specifically recorded values. In the example illustrated in FIG. **4**, the sequence Sq**10** is executed in accordance with an instruction SqI for "turning on" from the user, and the sequence Sq**20** and the subsequent sequences are executed in accordance with an instruction SqI for "printing" from the user. However, the plurality of sequences executed in response to the instruction SqI for "printing" from the user are terminated by an RUA command error in the sequence Sq**50**. As illustrated in FIG. **4**, in the first storage unit **561**, information of a combination of sequences to be executed in response to different instructions SqI from the user may be recorded. In the example illustrated in FIG. **4**, the combination of sequences to be executed in response to the different instructions SqI are the sequence Sq**10**, and the sequences Sq**20** to Sq**50**. The "combination of sequences" may include only one sequence such as the sequence Sq**10** executed in accordance with the instruction SqI for "turning on".

After more than a predetermined number of sequences are executed after the turning on of the printing device **500**, the main controller **590** performs the following process in step S**200**. That is, in step S**200**, when one sequence is completed, the main controller **590** deletes information indicating the earliest recorded sequence and included in information of sequences stored in the first storage unit **561**. As a result, in the first storage unit **561**, information of a predetermined number of sequences including the latest sequence among a plurality of sequences executed is recorded. An error occurs in the latest sequence among the plurality of sequences executed, and the latest sequence is not appropriately completed. In the example illustrated in FIG. **4**, the predetermined number is 5.

In step S**300** illustrated in FIG. **3**, the main controller **590** determines whether an error occurred in a sequence being executed. The error is detected by the first recording controller **563**, the second recording controller **564**, or the like (refer to a lower central part of FIG. **1**). To easily understand the techniques, detection of another error is not described in the present specification. When an error does not occur, the process proceeds to step S**400**. When an error occurs, the process proceeds to step S**500**. In the example illustrated in FIG. **4**, an error does not occur in the sequences Sq**10** to Sq**40** (refer to a left part of FIG. **4**).

In step S**400** illustrated in FIG. **3**, the main controller **590** determines whether all the one or more sequences to be executed in response to the instruction received from the user are already executed. When any of the one or more sequences to be executed is not executed, the process returns to step S**200**. In step S**200**, the main controller **590** executes the next sequence among the one or more sequences to be executed in response to the instruction received from the user in step S**100**. After the sequence is completed, the main controller **590** records information of the completed sequence in the first storage unit **561**.

In the example illustrated in FIG. **4**, first, an instruction for turning on is received from the user in step S**100** (refer to an upper right part of FIG. **4**). After the sequence Sq**10** is executed in step S**200**, step S**300** is executed and it is determined that all the one or more sequences are already completed in step S**400**. Then, the process illustrated in FIG. **4** ends.

After that, when an instruction for printing is newly received from the user in step S**100**, step S**200** and step S**400** are repeatedly performed unless an error occurs in the

sequence. In this manner, the sequences Sq**20** to Sq**40** are executed (refer to the second to fourth rows from the top in FIG. **4**). In the example illustrated in FIG. **4**, an RUA error occurs during the execution of the sequence Sq**50** in step S**200**, the process proceeds from step S**300** to step S**500** (refer to the lowest row illustrated in FIG. **4**).

In step S**500** illustrated in FIG. **3**, the main controller **590** records, in the second storage unit **562** of the printing device **500**, the numbers SqN of the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among the numbers SqN of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561**. The second storage unit **562** is a nonvolatile semiconductor memory (refer to a lower central part of FIG. **1**). In the first embodiment, the predetermined number is 5.

The main controller **590** records, in the second storage unit **562**, the content SqE of the error in the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** within the content SqE of the error in the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561**.

The main controller **590** records, in the second storage unit **562**, results SqR of the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among results of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561**.

Further, the main controller **590** records, in the second storage unit **562**, the instructions SqI from the user for the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among the instructions SqI from the user for the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561**.

FIG. **5** is a table illustrating an example of the information recorded in the second storage unit **562** of the printing device **500** after the processing in step S**500**. After the processing in step S**500**, in the second storage unit **562** of the printing device **500**, the content SqE of the error in the predetermined number of sequences, that is, the five sequences among the plurality of sequences recorded in the first storage unit **561**, the numbers SqN of the sequences, the results SqR of the sequences, and the instructions SqI from the user are recorded.

In step S**600** illustrated in FIG. **3**, the main controller **590** records, in the memory chip **130** of the ink cartridge **100**, the numbers SqN of the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among the numbers SqN of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561**. In the first embodiment, the predetermined number is 5. In this case, the numbers SqN of the sequences Sq**10** to Sq**50** continuously executed are recorded. The numbers SqN of the sequences Sq**10** to Sq**50** continuously executed are the numbers SqN of the sequences continuously recorded in the first storage unit **561**.

The main controller **590** records, in the memory chip **130**, the content SqE of the error in the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** within the content SqE of the error in the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561**.

FIG. **6** is a table illustrating an example of the information recorded in the memory chip **130** after the processing in step S**600**. After the processing in step S**600**, in the memory chip **130** of the printing device **500**, the content SqE of the error in the five sequences Sq**10** to Sq**50** among the plurality of sequences recorded in the first storage unit **561** and the numbers SqN of the five sequences Sq**10** to Sq**50** among the plurality of sequences recorded in the first storage unit **561** are recorded.

By performing the process, the plurality of sequences Sq**10** to Sq**50** executed before the error occurs can be known after the occurrence of the error based on the numbers SqN of the sequences recorded in the memory chip **130**. Therefore, as compared with a case where only the state of the printing device **500** after the error occurs and an error code of the error are recorded, it is possible to quickly and correctly estimate the cause of the occurrence of the error.

For example, a service representative can know, based on the numbers SqN of the sequences recorded in the memory chip **130**, which information was tried to be read from the memory in which process in accordance with a read command that caused an error. As a result, for example, when an error occurs in a read sequence, it is possible to identify that the error occurred in the read sequence due to a certain write sequence executed before the execution of the read sequence. The causes of errors that occur in the read sequence and the write sequence are, for example, noise that occurred in communication and poor contact with the memory terminals **290**.

In the present embodiment, the numbers SqN of the plurality of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** when the error occurs are recorded in the second storage unit **562** of the printing device **500** and the memory chip **130** of the ink cartridge **100** (refer to S**600** illustrated in FIG. **3** and a middle right part of FIG. **2**). Therefore, unlike a case where the numbers SqN of the plurality of sequences Sq**10** to Sq**50** are recorded only in the second storage unit **562** of the printing device **500**, when the ink cartridge **100** is sent to a person other than the user of the printing device **500**, the person can easily know the plurality of sequences Sq**10** to Sq**50** executed before the error occurs in the printing.

In the present embodiment, the numbers SqN of the plurality of continuous sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among the numbers SqN of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** are recorded in the memory chip **130** (refer to S**600** illustrated in FIG. **3** and a left part of FIG. **6**).

Therefore, the plurality of sequences Sq**10** to Sq**50** continuously executed before the error occurs can be known after the occurrence of the error based on the numbers SqN of the sequences recorded in the memory chip **130** of the ink cartridge **100**. Therefore, it is possible to accurately estimate the cause of the occurrence of the error, as compared with a case where numbers of sequences discretely selected from among a plurality of sequences executed are recorded in the memory chip **130**, for example, a case where one out of three among a plurality of sequences executed before an error occurs in printing is recorded in the memory chip **130**. In addition, processing for recording information is easy.

In step S**600** illustrated in FIG. **3**, the main controller **590** does not record, in the memory chip **130**, the results SqR of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the third column from the left of FIG. **4**).

The result SqR of executing each of the sequences includes a larger amount of information than that of the content SqE of the error and that of each of the numbers SqN of the sequences. Therefore, the capacity of the memory chip **130** can be reduced by performing the above-described process, as compared with a case where the results SqR of the sequences Sq**10** to Sq**50** are recorded in the memory chip **130**.

In addition, the main controller **590** does not record, in the memory chip **130**, the instructions SqI from the user for the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the fourth column from the left of FIG. **4**).

Each of the instructions SqI from the user includes a larger amount of information than that of the content SqE of the error and that of each of the numbers SqN of the sequences. Therefore, the capacity of the memory chip **130** can be reduced by performing the above-described process, as compared with a case where the instructions from the user for the sequences are recorded in the memory chip **130**.

In such an aspect, when an error does not occur due to the replacement of the ink cartridge **100** after the occurrence of an error, it is possible to perform printing with an ink cartridge **100** attached to the printing device **500** after the replacement. The ink cartridge **100** used when the error occurs can be sent to the manufacturer of the printing device **500**. The manufacturer of the printing device **500** can analyze the cause of the error based on the information stored in the memory chip **130** of the ink cartridge **100**.

In the present embodiment, the following effects can be obtained by recording the information described above in the second storage unit **562** of the printing device **500** (refer to step S**500** illustrated in FIG. **3**, and FIG. **6**).

That is, the cause of the occurrence of an error that cannot be accurately estimated only from information recognized from numbers SqN of sequences recorded in the memory chip **130** of the ink cartridge **100** can be accurately estimated based on results SqR of the sequences recorded in the second storage unit **562** of the printing device **500** (refer to FIG. **6**).

In addition, the cause of the occurrence of an error that cannot be accurately estimated only from information recognized from numbers SqN of sequences recorded in the memory chip **130** of the ink cartridge **100** and results SqR of the sequences recorded in the second storage unit **562** of the printing device **500** can be accurately estimated (refer to FIG. **6**). That is, the cause of the occurrence of the error can be accurately estimated based on an instruction SqI provided from the user and recorded in the second storage unit **562** of the printing device **500** (refer to FIG. **6**).

In such an aspect, when an error occurs, the manufacturer of the printing device **500** recalls the ink cartridge and analyzes the cause of the error. Then, when it is not possible to identify the cause of the error, the manufacturer dispatches a service representative to the user of the printing device **500** and can identify the cause of the occurrence of the error based on results SqR of sequences recorded in the second storage unit **562** of the printing device **500** and an instruction SqI from the user. When the printing device **500** is large, the service representative may acquire information from the second storage unit **562** of the printing device **500**, bring the information back to a service station, and analyze the cause of the error. When the printing device **500** is small, the service representative may bring the printing device **500** back to the service station or arrange delivery of the printing device **500** to the service station.

The ink cartridge **100** according to the present embodiment is also referred to as a "cartridge". The first recording controller **563** and the second recording controller **564** are also referred to as "error detectors". The operation unit **570** and the connector **575** are also referred to as "interface units". The main controller **590** is also referred to as a "controller". The memory chip **130** is also referred to as a "cartridge storage unit".

B. Other Embodiments

B1. Other Embodiment 1

(1) In the embodiment described above, information regarding the same number of sequences is recorded in the first storage unit **561**, the second storage unit **562**, and the memory chip **130** (refer to Sq**10** to Sq**50** illustrated in FIGS. **4** to **6**). The number of sequences is 5. However, the number of sequences of which information is recorded in the first storage unit of the printing device, the number of sequences of which information is recorded in the second storage unit of the printing device, and the number of sequences of which information is recorded in the cartridge storage unit of the cartridge may be other numbers, such as 3, 6, and 8. In addition, the number of sequences of which information is recorded in the first storage unit of the printing device, the number of sequences of which information is recorded in the second storage unit of the printing device, and the number of sequences of which information is recorded in the cartridge storage unit of the cartridge may be different. However, it is preferable that the number of sequences of which information is recorded in the second storage unit of the printing device be equal to or larger than the number of sequences of which information is recorded in the cartridge storage unit of the cartridge.

(2) In the embodiment described above, in step S**600** illustrated in FIG. **3**, the main controller **590** does not record, in the memory chip **130**, the results SqR of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the third column from the left of FIG. **4**, and FIG. **6**). However, in step S**600** illustrated in FIG. **3**, the main controller **590** may record the results SqR of the sequences in the memory chip **130**.

In the embodiment described above, in step S**600** illustrated in FIG. **3**, the main controller **590** does not record, in the memory chip **130**, the instructions SqI from the user for the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the rightmost column illustrated in FIG. **4**, and FIG. **6**). However, in step S**600** illustrated in FIG. **3**, the main controller **590** may record, in the memory chip **130**, the instructions SqI from the user to execute the sequences.

(3) In the embodiment described above, the techniques disclosed herein are described using the RUA command error as an error to be detected (refer to a lower left part of FIG. **4**). However, the error to be detected may be another error such as a paper feeding error, an error regarding reciprocation of the carriage, or an error regarding ejection of ink. The techniques disclosed herein are more effective when the techniques disclosed herein are applied to recording of an error of sequences that may be executed in different types of processes.

(4) In the embodiment described above, the printing device **500** is described as an ink jet printer to which the ink cartridge **100** is attached. However, as the cartridge detachably attached to the printing device, another cartridge such as a toner cartridge or a drum cartridge to be attached to a laser printer may be used. However, it is preferable that the cartridge detachably attached to the printing device be used for printing.

B2. Other Embodiment 2

In the embodiment described above, in the memory chip **130** of the ink cartridge **100**, the numbers SqN of the

predetermined number of continuous sequences Sq**10** to Sq**50** are recorded (refer to FIG. **6**). However, numbers of discontinuous sequences among a plurality of sequences executed may be recorded in the memory chip **130**, for example, one out of three of a plurality of sequences executed before an error occurs or only a sequence that satisfies a predetermined condition may be recorded in the memory chip **130**.

B3. Other Embodiment 3

In the embodiment described above, in step S**500** illustrated in FIG. **3**, the main controller **590** records, in the second storage unit **562**, the results SqR of the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among the results SqR of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the third column from the left of FIG. **5**). However, the controller may not record, in the second storage unit, the results of the sequences recorded in the first storage unit.

B4. Other Embodiment 4

In the embodiment described above, in step S**500** illustrated in FIG. **3**, the main controller **590** records, in the second storage unit **562**, the instructions SqI from the user for the predetermined number of sequences Sq**10** to Sq**50** including the latest sequence Sq**50** among the instructions SqI from the user for the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the rightmost column illustrated in FIG. **5**). However, the controller may not record, in the second storage unit, the instructions from the user to start the sequences recorded in the first storage unit.

B5. Other Embodiment 5

In the embodiment described above, in step S**600** illustrated in FIG. **3**, the main controller **590** does not record, in the memory chip **130**, the results SqR of the plurality of sequences Sq**10** to Sq**50** recorded in the first storage unit **561** (refer to the third column from the left of FIG. **4**, and FIG. **6**). However, the controller may record, in the cartridge storage unit, the results of the sequences recorded in the first storage unit.

C. Other Embodiments

The present disclosure is not limited to the embodiments described above and can be implemented in various forms without departing from the gist of the present disclosure. For example, the present disclosure can be implemented in the following forms. The technical features of the above-described embodiments corresponding to technical features in aspects described below can be appropriately replaced or combined in order to solve some or all of the problems described in the present disclosure or obtain some or all of the effects described in the present disclosure. In addition, the technical features can be removed unless the technical features are described as essential features in the present specification.

(1) According to an aspect of the present disclosure, a printing system is provided. The printing system includes a printing device that performs printing and a cartridge that is used for the printing and detachably attached to the printing device. The printing device includes a controller that controls the printing device to perform the printing by executing a plurality of sequences, an error detector that detects an error that is likely to occur in one or more of the plurality of sequences, and a first storage unit in which information is recorded by the controller. The cartridge includes a cartridge storage unit that is a nonvolatile storage unit and in which information is recorded by the controller in a state in which the cartridge is attached to the printing device. The controller records, in the first storage unit, numbers and results of a plurality of sequences including the latest sequence among the plurality of sequences executed. When the error is detected, the controller records, in the cartridge storage unit, numbers of a predetermined number of sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit.

According to this aspect, a plurality of sequences executed before an error occurs can be known after the occurrence of the error based on numbers of sequences recorded in the cartridge storage unit. Therefore, it is possible to accurately estimate the cause of the occurrence of the error, as compared with a case where only the state of the printing device after the occurrence of the error and an error code of the error are recorded.

In addition, in the aspect described above, numbers of a plurality of sequences including the latest sequence when an error occurs are recorded in the cartridge storage unit of the cartridge. Therefore, unlike a case where numbers of a plurality of sequences are recorded only in the printing device, when the cartridge is sent to a person other than the user of the printing device, the person can easily know a plurality of sequences executed before an error occurs in printing.

(2) In the printing system according to the aspect described above, when the error is detected, the controller may record, in the cartridge storage unit, numbers of a plurality of continuous sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit.

According to this aspect, a plurality of sequences continuously executed before an error occurs in printing can be known after the occurrence of the error based on numbers of sequences recorded in the cartridge storage unit of the cartridge. Therefore, it is possible to accurately estimate the cause of the occurrence of an error, as compared with a case where numbers of sequences discretely selected from among a plurality of sequences executed before the error occurs are recorded in the cartridge storage unit.

(3) In the printing system according to the aspect described above, the printing device may include a volatile storage unit as the first storage unit, and a second storage unit that is a nonvolatile storage unit and in which information is recorded by the controller. When the error is detected, the controller may record, in the second storage unit, results of the predetermined number of sequences including the latest sequence among the results of the plurality of sequences recorded in the first storage unit.

According to this aspect, the cause of the occurrence of an error that cannot be accurately estimated only from information recognized from numbers of sequences recorded in the cartridge storage unit of the cartridge can be accurately estimated based on results of sequences recorded in the second storage unit of the printing device.

(4) In the printing system according to the aspect described above, the printing device may include an

interface unit that receives one or more instructions from a user, and the controller may record, in the first storage unit, the one or more instructions from the user that triggered a plurality of sequences including the latest sequences among the plurality of sequences executed. When the error is detected, the controller may record, in the second storage unit, an instruction from the user for the predetermined number of sequences including the latest sequence among the one or more instructions from the user for the plurality of sequences recorded in the first storage unit.

According to this aspect, the cause of the occurrence of an error that cannot be accurately estimated only from information recognized from numbers and results of sequences can be accurately estimated based on an instruction received from a user and recorded in the second storage unit of the printing device.

(5) In the printing system according to the aspect described above, when the error is detected, the controller may not record, in the cartridge storage unit, the results of the sequences recorded in the first storage unit.

According to this aspect, the capacity of the cartridge storage unit can be reduced, as compared with a case where the numbers and results of the predetermined number of sequences including the latest sequence among the numbers and results of the plurality of sequences recorded in the first storage unit are recorded in the cartridge storage unit.

(6) A method of controlling a printing system including a printing device that performs printing and a cartridge that is used for the printing and detachably attached to the printing device includes (a) recording, in a first storage unit included in the printing device, numbers and results of a plurality of sequences including the latest sequence among a plurality of sequences executed in the printing device, and (b) recording, in a cartridge storage unit that is included in the cartridge attached to the printing device and is a nonvolatile storage unit, numbers of a predetermined number of sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit when an error occurs in a sequence.

(7) In the control method according to the aspect described above, (b) may include recording, in the cartridge storage unit, numbers of a plurality of continuous sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit when the error occurs.

(8) In the control method according to the aspect described above, the printing device may include a volatile storage unit as the first storage unit, and a second storage unit that is a nonvolatile storage unit and in which information is recorded. The control method may include (c) recording, in the second storage unit, results of the predetermined number of sequences including the latest sequence among the results of the plurality of sequences recorded in the first storage unit when the error occurs.

(9) In the control method according to the aspect described above, the printing device may include an interface unit that receives one or more instructions from a user. The control method may include (d) recording, in the first storage unit, the one or more instructions from the user that triggered a plurality of sequences including the latest sequence among the plurality of sequences executed in the printing device, and (e) recording, in the second storage unit, an instruction from the user for the predetermined number of sequences including the latest sequence among the one or more instructions from the user for the plurality of sequences recorded in the first storage unit when the error occurs.

(10) In the control method according to the aspect described above, in (b), the results of the sequences recorded in the first storage unit may not be recorded in the cartridge storage unit.

The present disclosure can be implemented in various forms other than the printing system and the method of controlling the printing system. For example, the present disclosure can be implemented in the forms of a method of recording an error, a method of analyzing a cause of an error, a computer program that implements these methods, a non-transitory recording medium having the computer program recorded therein, and the like.

What is claimed is:

1. A printing system comprising:
a printing device that performs printing; and
a cartridge that is used for the printing and detachably attached to the printing device, wherein
the printing device includes
a controller that controls the printing device to perform the printing by executing a plurality of sequences,
an error detector that detects an error that is likely to occur in one or more of the plurality of sequences, and
a first storage unit in which information is recorded by the controller,
the cartridge includes a cartridge storage unit that is a nonvolatile storage unit and in which information is recorded by the controller in a state in which the cartridge is attached to the printing device,
the controller records, in the first storage unit, numbers and results of a plurality of sequences including the latest sequence among the plurality of sequences executed, and
when the error is detected, the controller records, in the cartridge storage unit, numbers of a predetermined number of sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit.

2. The printing system according to claim **1**, wherein
when the error is detected, the controller records, in the cartridge storage unit, numbers of a plurality of continuous sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit.

3. The printing system according to claim **1**, wherein
the printing device includes
a nonvolatile storage unit as the first storage unit, and
a second storage unit that is a nonvolatile storage unit and in which information is recorded by the controller, and
when the error is detected, the controller records, in the second storage unit, results of the predetermined number of sequences including the latest sequence among the results of the plurality of sequences recorded in the first storage unit.

4. The printing system according to claim **3**, wherein
the printing device includes an interface unit that receives one or more instructions from a user,
the controller records, in the first storage unit, the one or more instructions from the user that triggered a plurality of sequences including the latest sequence among the plurality of sequences performed, and
when the error is detected, the controller records, in the second storage unit, an instruction from the user for the

predetermined number of sequences including the latest sequence among the one or more instructions from the user for the plurality of sequences recorded in the first storage unit.

5. The printing system according to claim **1**, wherein

when the error is detected, the controller does not record, in the cartridge storage unit, the results of the sequences recorded in the first storage unit.

6. A method of controlling a printing system including a printing device that performs printing and a cartridge that is used for the printing and detachably attached to the printing device, the control method comprising:

(a) recording, in a first storage unit included in the printing device, numbers and results of a plurality of sequences including the latest sequence among a plurality of sequences executed in the printing device; and

(b) recording, in a cartridge storage unit that is included in the cartridge attached to the printing device and is a nonvolatile storage unit, numbers of a predetermined number of sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit when an error occurs in a sequence.

7. The control method according to claim **6**, wherein

(b) includes recording, in the cartridge storage unit, numbers of a plurality of continuous sequences including the latest sequence among the numbers of the plurality of sequences recorded in the first storage unit when the error occurs.

8. The control method according to claim **6**, wherein

the printing device includes

a nonvolatile storage unit as the first storage unit, and

a second storage unit that is a nonvolatile storage unit and in which information is recorded, and

the control method further comprises (c) recording, in the second storage unit, results of the predetermined number of sequences including the latest sequence among the results of the plurality of sequences recorded in the first storage when the error occurs.

9. The control method according to claim **8**, wherein

the printing device includes an interface unit that receives one or more instructions from a user, and

the control method further comprises:

(d) recording, in the first storage unit, the one or more instructions from the user that triggered a plurality of sequences including the latest sequence among the plurality of sequences executed in the printing device; and

(e) recording, in the second storage unit, an instruction from the user for the predetermined number of sequences including the latest sequence among the one or more instructions from the user for the plurality of sequences recorded in the first storage unit when the error occurs.

10. The control method according to claim **6**, wherein

in (b), the results of the sequences recorded in the first storage unit are not recorded in the cartridge storage unit.

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